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A4_15 Lunar Landers

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Abstract
Some have suggested that the moon landings were hoaxed. This paper investigates whether it would be possible to put an end to the debate on this issue by imaging the lunar excursion module (LEM) on the Moon. In order to do this with an optical telescope, it is found that the required aperture would be 57 m. This is compared to the largest effective aperture of an optical telescope on Earth and it is found to be unfeasible using current telescopes.

Introduction

Some have suggested that the moon landings were hoaxed. This paper considers the possibility of disproving this hypothesis by imaging the lunar excursion module (LEM) on the moon. By working out the angle that the LEM would subtend in the night sky, the telescopic aperture required in order to be able to image the LEM from Earth can be calculated. If the required aperture is lower than the highest effective aperture on Earth, the acquired images could be used to confirm or deny the moon landings took place.

In this paper, the effect of atmospheric distortion on the observations is neglected, and it is assumed that adaptive optics would be able to compensate for any issues related to this phenomenon. Work on this assumption could be performed in the future. The author also notes that images of some of the LEMs (and landing sites) have already been acquired by NASA's Lunar Reconnaissance Orbiter [1], but it is assumed that any moon hoax theorist who is unwilling to take NASA's word for the lunar landings would also be unwilling to trust NASA-sourced images.

Angle Calculation

In order to calculate the angle that the LEM would subtend in the night sky it is necessary to use trigonometry. It is known that the LEM was $l = 4.2$ m in diameter [2]. Since using the LEM's full length l would result in an isosceles triangle, it is necessary to consider half that length in the trigonometry. Then the half the length of the LEM is the opposite side of the right-angled triangle and it can be used to find half the angle θ subtended by the LEM.

The distance from the Earth's surface to the Moon's surface is the adjacent side of the right-angled triangle. It is known that at perigee, the Moon is a distance 3.633×10^8 m from the Earth [3]. The Earth's volumetric mean radius is 6.371×10^6 m, and the Moon's is 1.737×10^6 m [3]. Subtracting the two radii values from the value of distance at perigee, it can be seen that $d = 3.552 \times 10^8$ m. As such,

$$\frac{\theta}{2} = \tan^{-1}\left(\frac{l}{2d}\right). \quad (1)$$

Putting the values quoted above into Eq. (1) a value of $\theta = 1.18 \times 10^{-8}$ radians is obtained.

Resolution

The relationship between the angle subtended by the desired observation target and the required aperture of the telescope being used is Rayleigh's criterion [4],

$$\theta = \frac{1.22\lambda}{D} \Longrightarrow D = \frac{1.22\lambda}{\theta}, \quad (2)$$

where θ is the subtended angle given above and must be in radians, λ is the wavelength of the light (in this case, 390 nm, the shortest possible wavelength for visible light) and D is the required aperture of the telescope to achieve that angular resolution. Substituting values for the angle and wavelength into Eq. (2) gives a required aperture $D = 40.2$ m.

Discussion

The largest aperture of an optical telescope on Earth is that of the Gran Telescopio Canarias (GTC) [5], situated in the Canary Islands with a mirror comprised of 36 hexagonal components achieving an effective optical aperture of 10.4 m. This is clearly far below the required aperture of 40.2 m found above, and means that it is currently impossible to image the LEM on the lunar surface from Earth.

However, there is another telescope, the Large Binocular Telescope (LBT), which has an effective aperture of 22.8 m [6]. Although this is still not enough to resolve the LEM on the lunar surface, it has been shown in theory that the binocular set-up of the LBT could be expanded to produce a telescope with an effective aperture of 100 m [7].

Conclusion

Although it is currently impossible to observe the LEM

from the Earth's surface and thus confirm or deny the Moon landings via direct observation due to both the GTC and the LBT being too small to perform this task, it is theoretically possible that an observational telescope in the future may be able to make the observations and thus put the matter to rest.

REFERENCES

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